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(54) Dot-Matrix LED Display Unit and a Large LED Display Device Created by Combining such Units

Dot-matrix LED display unit, and a large LED display device created by combining such units, wherein each unit contains an LED display board including a plurality (in practice $4 \cdot 2 = 8$) of standard $8 \cdot 8$ LED dot-matrix panels and a control circuit including the elements necessary to control the LED display board, and additionally including an input terminal and output terminal, an addressing device in which an identification code is stored, and devices to adjust the color/brightness of the dots on the unit. The units may be employed to create a large LED display device by connecting a plurality of such elements in series or in parallel. Since each unit is scanned separately, the size of the large LED display device is quite flexible, and local nonuniformity in the color/brightness of the device may be eliminated by adjusting the appropriate units.

Description

The invention relates to a dot-matrix LED display unit, specifically, a color dot-matrix LED display unit, any number of which may be combined to create a large dot-matrix LED display unit of any desired size. The invention is a continuation-in-part application of US patent application, serial number 07/109,517.

LED displays are currently employed in a wide range of areas. In this technology, any type of color image may be generated by a number of LED dots in an LED dot matrix. An LED dot may contain three LED chips for the different monochromatic light types, particularly, red, green, and blue. Since all colors may be generated using these three primary chromatic light types, it is possible to generate the desired color using these LED dots by mixing different fractions of the three primary chromatic light types.

(Note: It is currently only possible to fabricate red and green LED chips cheaply, whereas the fabrication of blue LED chips is still very expensive. For economic reasons, most commercial LED displays are equipped only with red and green LED chips, and not blue ones. A considerable number of so-called "warm colors" such as yellow, orange, yellow-green, and a number of intermediate colors may still be generated using the red and green LED chips. However, it is not possible to produce the so-called "cool colors" such as magenta, cyan, violet, and indigo without the blue component. Figure 9 shows an LED dot (D) with a red (R) and a green (G) LED chip.) Large color, dynamic, dot-matrix LED displays are currently available which generate a pattern which is stored in a computer and coordinated with the dynamically displayed pattern on the monitor of the computer. (The term "dynamic" means that the image on the display changes over time, as do the images on a television screen. It thus has the opposite meaning of the term "static" which denotes an image on a display which is not time-dependent, as is applicable in the case of photography.) Figure 11 shows a large dynamic dot-matrix LED display (L) having a series of dot-matrix LED display panels. (For reasons of visual simplicity, only nine panels (P11) through (P33) are shown in the example illustrated. In the actual application, the number of panels arranged in a large LED display device are significantly greater than nine. In fact, the resolution provided by nine panels (only 24 x 24 = 576 dots) is not even close to being capable of displaying the cartoon figure "Bugs Bunny" as shown.)

The panels are standardized dot-matrix LED display elements. Each panel contains 8 x 8 = 64 LED dots (D). Each dot may contain two (red and green, as in Figure 9) or three (red, green, and blue) LED chips. Generation of the image on the large LED display device (L) is achieved by cyclically scanning all the LED dots in the large LED display device from top to bottom. Scanning in the large LED display device differs from scanning a TV screen in that in the first case, scanning is performed by rows, whereas in

the second case scanning is performed dot by dot. Since the scanning is a known technology, no detailed explanation is required.

Since computer signals (C) are not capable of being transmitted over a relatively great distance from the computer (C) to the large LED display device (L), an interface (I) must be interconnected which relays the computer signals in a form suitable for a relatively long line. The "pattern" in the computer is analyzed as a "half-tone" image generated by a number (for example, 24 x 24 = 576) of dots. The color (color quality) and brightness (luminance) for each dot coincide with the values for the corresponding dot on the pattern, and are determined by the brightness of the LED chip (R) (G). The brightness of an LED chip may be divided into eight classes from completely dark to maximum brightness, specifically, O, L, M, N, P, Q, R, and S. The brightness of a chip depends on the current supplied to it. As the current supplied increases, the brightness of the chip increases. If the brightness of the red LED chip (R) of an LED dot corresponds to the M class, and the brightness of a green LED chip (G) corresponds to the P class at a given moment, the result is a color brightness of the MP class. Given a differentiation into eight brightness levels, 8 x 8 = 64 different classes of color brightness may be defined. (Note: In this case, the term "color brightness" must be employed instead of "color" in order to describe the 64 different classes, since it cannot be claimed that there are 64 different colors. Since the corresponding hue of chromatic light is only based on the ratios of the primary monochromatic light types, in the LL class and RR class the same color (yellow) occurs, but at different brightnesses. The color brightness of the LED dots is controlled by color brightness signals (data) which are transferred to the corresponding dots via a data shift circuit (DS). Scanning of the rows is controlled by row scanning signals which activate the appropriate rows by means of a scanning driver circuit (SC). The row scanning signals activate the 24 rows of LED dots of the LED display sequentially moving from the top row (R1) to the bottom row (R24), and then repeat this action. When a given row (for example, the first row of dots of the LED panel (P21), (P22), (P23), i.e., the ninth row (R9) of the large LED display device (L)) is activated, the data for the corresponding LED dots in this row (i.e., the brightness signals for these dots) is transmitted to the 24 LED dots of this row (R9). The scanning and transmission of the data are controlled by the software of the central processing unit (CPU). The output of the CPU is connected through a buffer (B1) to the data shift circuit (DS) and to a random access memory (RAM), the output of which is connected through another buffer (B2) to a scanning driver circuit (SC). The components, which are shown in the area defined by the broken line (i.e., the CPU, RAM, data shift circuit (DS) and buffer (B1), (B2)) form the control circuit (CC) of the large LED display device and may be located on a single circuit board. The supply of current to the control circuit is effected

by a current stabilizer (S). All of the elements listed above are known in the computer industry, and for this reason, no detailed description of them is required.

The software in the CPU must be programmed so that the 24 dot rows are scanned in a specific period, and so that when a dot row is scanned by the scanning driver circuit the appropriate data (i.e., color brightness signals) for the LED dots of this row are transmitted to the corresponding LED dots.

Despite the fact that such large LED display devices are increasingly being used in a wide range of areas, they do have a number of disadvantages. The first disadvantage is that their size is not able to be modified.

Since the complete large LED display device is scanned with a defined number of dot rows and columns, it is not possible to increase or reduce its size by adding or removing certain dot matrix LED display panels without having to modify the hardware and software of the control circuit (CC). For example, if the scale of the large LED display device (L) is increased to 32 x 32 = 1024 dot matrix panels (i.e., 4 x 4 = 16 panels), or its scale is reduced to 16 x 16 = 252 dot matrix panels (i.e., 2 x 2 = 4 panels), the resulting new large LED display device becomes incompatible with the original control circuit (CC). The reason for this is simple. A television receiver with the NTSC system cannot be used to handle a program from a television station using the SECAM system since the number of columns and rows (scanning standard) for the two systems is different. In analogous fashion, it is also impossible to use a control circuit (CC) which was specially developed for a 24 x 24 dot matrix to control a large LED display device with 32 x 32, or a 16 x 16 dot matrix. As a result, if the goal is to enlarge the scale of the large LED display device (L) to 32 x 32 dots, the buffers (B1), (B2) of the data shift circuit (DS) and the scanning driver circuit (SC) must be modified so that they are compatible with the dots arranged in 32 rows and 32 columns in the enlarged LED display device, and the software in the CPU must be reprogrammed so that the scan cycle covers 32 instead of 24 rows. In addition, the circuit board supporting the elements (B1), (B2), (DS), (SC), RAM and CPU must be redesigned. The result is that economically viable modification of the size of the large LED display device (L) is impossible.

For the reasons indicated, large LED display devices lack flexibility in terms of their size and specification. If a specified size is fabricated only in small numbers, the unit price becomes very high. As a result, large LED display devices are available on the market only in a few specific standard sizes.

In addition to the impossibility of modifying their size, another disadvantage of the traditional, dynamical dot matrix LED displays is that they require a high degree of conformance between the LED display panels, and that it is impossible to modify the color brightness of a specific zone (or of a specific LED display panel) in a large LED display device (L). For the LED industry manufacturer, there remains a technical

difficulty, which to date has yet not been solved, relating to the fact that it is impossible to control the quality of an LED display panel in such a way that its color brightness may be accurately set during the manufacture of the LED display panel to a defined value (or within a very narrow range). As a result, the color brightness of the dots of an LED display panel (P11) may differ from that of another LED display panel (P12) (brighter or darker than the last one, or redder or greener than the last one) even when the two LED display panels are supplied with the same voltage and the same current. The nonuniformity in color brightness of the LED display panels may produce unpleasant visual effects on the LED display. For example, when the color brightness of the dots of a panel (P11) are darker and redder than those on panel (P13), the right ear of the rabbit Bugs Bunny will appear darker and redder than his left ear for no reason. As indicated above, it is impossible to control the resulting quality of an LED display panel during its production; as a result, it is definitely impossible to fabricate an LED display panel whose color brightness meets our requirements. The only possible approach is to select an LED display panel from a series of complete LED display panels to obtain the desired color brightness. The manufacturers of LED display panels generally subdivide their products into different levels (for example, ten) corresponding to their brightness in response to being energized at a standardized voltage. The manufacturers of large LED display devices (the purchasers of the panels) must select the panels with the same level to construct a large LED display device. Since all panels must strictly conform to the same level, a situation may arise in which the manufacturers of large LED display devices become unwelcome customers of the panel manufacturers since the former purchase only products of a specific level from the latter. As a result, the panel manufacturers have to raise the price for this specific type of product of which they have a relatively limited inventory. In addition, the manufacturers of the large LED display devices frequently have to expect shortages of the desired specific panel levels.

In addition, even when all the panels (P11) through (P33) have been strictly selected so as to have the same color brightness level, the overall surface of the resulting large LED display device may not have a consistently uniform color brightness when energization is effected at the same voltage – a result attributable to certain unforeseeable factors. For example, the panel (P11) may be slightly darker than panel (P13) when both are mounted in a large LED display device, even when they originally had been assigned to the same color brightness class. In this case, the brightness of the individual panels must be adjusted. However, separate adjustment of individual panels is impossible since the complete large LED display device (all panels) is scanned as a whole. As a result, only the color brightness of the complete large LED display device (L) is able to be adjusted. In other words, is only possible to modify all nine panels (P11) through (P33) together at the same time in terms of their color brightness since the entire large LED display device (L) is scanned as a whole.

For the above reasons, there is tremendous interest in large LED display devices which may be arbitrarily enlarged or reduced to any desired size without the necessity of finding a new design for the circuit. It is furthermore desirable to have the color brightness of different parts of the large LED display device be capable of separate adjustment so that the panels are not required to have the same level of color brightness, and so that local nonuniformity in the color brightness of the large LED display device may be compensated by local adjustment in a given area.

To solve these problems, the design principle of the traditional large LED display device must be replaced. It is the principle by which all dots of the LED display panels (P11) through (P33) are scanned as a whole, thereby providing no flexibility in the large LED display device with respect to size. In addition, the principle whereby the entire large LED display device (L) is driven by a single control circuit (CC) is responsible for the fact that local adjustment in terms of color and brightness is impossible. For these reasons, the design principles of the conventional large dynamic dot matrix LED display device must be abandoned.

According to the invention, a large LED display device is created by combining a number of identical units. Each unit may contain N standard 8 x 8 LED dot matrix panels, where N is a small positive integer. The number N is preferably neither too large nor too small (the reason for this is explained below). Thus, N = 8 when the unit contains, for example, 2 x 4 = 8 panels, and the resulting unit is a 16 x 32 = 512 dot matrix. The essential principle of the invention is that each unit has its own control circuit with an input terminal and output terminal. Two units may be connected to each other in series (i.e., the output of one unit is connected to the input of the other unit) or they may be connected in parallel (i.e., the input terminals of the two units may be connected to each other.) As a result, any desired number of units may be interconnected to create a large LED display device of the desired size. Each unit is scanned as a whole. (In other words, given a unit of 16 x 32 dots, the 16 rows are scanned sequentially from the top row (first) to the bottom row (16^{th} row), after which the scanning action is begun again at the first row.) Since all units in the large LED display device are scanned separately, the size of the large LED display device may be modified at will by adding or removing its units, without any problem of incompatibility arising.

Since each unit is scanned independently as a whole, the control circuit of each unit must contain the same elements as contained in the control circuit known from prior art. The control circuit (CC) of each unit must therefore contain a CPU, a RAM, a scanning driver circuit, a data shift circuit and the requisite buffers, just as does the conventional large LED display device. (As a result, a unit according to the invention may be viewed as a miniaturized conventional large LED display device (L) as in Figure 10.) The power

supply for each control circuit is effected by a current source (or a current stabilizer). The scanning driver circuit performs a cyclic scanning motion through the 16 rows, during which the data shift circuit transmits the data (color brightness signals) to the 32 dots of the corresponding row. The CPU software is specifically programmed for a 16 x 32 dot matrix. If the number of panels in the unit deviates from this (for example, 4 panels instead of 8), the CPU software must be reprogrammed accordingly so as to conform to this "scanning standard."

In addition, the control circuit of each unit is provided with a color brightness scheme by which to adjust the color and brightness of the unit. Since a unit is scanned as a whole, the individual units of a large LED display device may be adjusted separately, whereas the 8 panels of a unit are adjusted at the same time and may not be adjusted separately. In practice, the color brightness switching scheme contains multiple ON/OFF switches, the positions of which correspond to the different color brightness levels.

Since the individual units in the large LED display device may be adjusted differently, it is not necessary for all panels of the large LED display device to match the same level. It is only the 8 panels of a unit that must have the same level so as to ensure uniformity in terms of the color and brightness of each unit. In addition, when certain sections of the large LED display device are not uniform, the units of these sections may be adjusted separately to make them conform to the remaining sections.

One problem which occurs with a large LED display created from such units is how a unit selectively receives data intended for it from the computer while rejecting the data of the other units. A conventional large LED display device (L) as in Figure 10 contains only one unit (in other words, the entire large LED display device (L) is a single "unit"), so that this problem does not exist. In the case of the present invention, however, each unit must be capable of receiving the data intended for it and rejecting the data of other units. If one assumes, as in Figure 1A, that a large LED display device (L1) is created, according to the invention, out of 4 x 2 = 8 units (U1) through (U8) (see associated illustration) by connecting the units in parallel or in series, then the data sent by the computer to unit (U6) may be sent to all the units. (For example, they may pass through (U1), (U2) up to (U6), or through (U1), (U3), and (U7) up to (U8).) The data is able to be received only by unit (U6) since the remaining units reject the data not intended for them. To accomplish this, a unit must be capable of recognizing whether or not the transmitted data is intended for it. For this reason each unit has an "identification code," and the transmitted data is accompanied by an "addressing signal." When the identification code matches the addressing signal, a unit accepts the transmitted information. Otherwise the information is rejected and passed on. Thus the data intended for unit (U6) passes through unit (U1) without being accepted, then trifurcates to units

(U2), (U3), and (U4) where the data is not accepted, and is passed on to (U5), (U6) , (U7) and (U8), out of which only unit (U6) receives the data.

Before the eight units (U1) through (U8) are positioned on the large LED display device (L1), the positions for these units must be assigned to the corresponding addresses in the memory of the computer so that the data intended for a given unit is able to be correctly generated in the relevant position. Assuming that the eight positions for the large LED display device (L1) in the associated drawing of Figure 1A are assigned to the eight addresses 000, 001, 010, 011, 100, 101, 110, and 111 in the memory (M) of the computer, then the data intended for each unit must first be assigned to an address. For example, the data for unit (U6) must be linked to address 101. (The assignment of the data for the eight units to eight addresses may be termed the "assignment plan.") This means that when the data for unit (U6) are transmitted, an "addressing signal" matching address 101 is transmitted simultaneously.

To ensure that the transmitted data is accepted by the appropriate unit, each unit must be provided with a respective identification code which matches an address. For example, unit (U6) must receive identification code 101 so as to enable unit (U6) to receive the data with the addressing signal of address 101.

It is worth noting that the "assignment plan" is determined only by the positions or the units on the large LED display device (L1) and by the codes of the units – the wiring of the units has no effect. For example, if the wiring of the units is converted to a series circuit comprising U1-U2-U2-U4-U5-U5-U7-U8, the "assignment plan" in the memory (M) of the computer does not change as long as the positions of the units on (L2) remain the same and the codes are not changed. If, on the other hand, the positions of codes for the units change, then the "assignment plan" also changes, even if the wiring of the units remains unchanged.

The "assignment plan" may be sketched in a "mapping program" cycle. After the data intended for the units and the data linked to the position of the units on (L1) are entered in the computer, one and only one cycle of the "mapping program" must be run in the "mapping program" for the computer to assign the data intended for each unit to the appropriate address. (In other words, it sketches an "assignment plan" in its memory.) According to the "assignment plan," the data of a given unit is accompanied by a corresponding addressing signal which enables the unit to recognize whether or not the data is intended for it.

In the event the user modifies the size of the large LED display device (L1) by adding or removing individual units, or simply changes the positions of the units in (L1) without adding or removing units in (L1), or simply changes the code for these units, then the assignment changes, and the user can no longer use the old assignment plan to generate the data in the correct units. As a result, he must enter the data for the new units and the data for the positions of the units, and run the mapping program once again

in order to sketch a new assignment plan. The units thus again receive the capability of selectively accepting or rejecting the data transmitted by the computer.

The "mapping program" is not absolutely necessary. If an "assignment plan" for the units can be entered into the memory of the computer, the mapping program may be dispensed with. An "assignment plan" of this type, however, must be replaced accordingly by another "assignment plan" if the arrangement of the units is changed.

(Note: In fact, the "assignment plan" is a program which reflects the assignment of the data intended for the units as well as the corresponding addresses. This "plan program" must not be confused with the "mapping program." The mapping program does not provide any specific assignment between the units and addresses. "Mapping" does not signify a plan but the capacity to draw up a plan. It enables the computer to sketch the assignment of the units to the addresses of the computer. When cycling through the "mapping program," the computer sketches a "plan program" for the units in the memory. The "assignment plan" must be changed if the assignment of the units to the computer addresses changes, whereas the "mapping program" does not have to be changed when the assignment is changed.)

Practically speaking, the "identification code" for each unit corresponds to the state of an address switching scheme having multiple hand-operated ON/OFF switches. If the address switching scheme for each unit contains three ON/OFF switches the result is eight different binary codes, specifically, 000, 001, 010, 011, 100, 101, 110, and 111 each of which corresponds to one unit (U1) through (U8). Needless to say, no "overlap" or "collision" of codes is permitted. In other words, two units may not have the same code, unless they are supposed to always represent the same pattern. For this reason, all units must receive different identification codes. If the address switching scheme contains eight ON/OFF switches, then $(2)^8 = 256$ different eight-bit codes are available. This means that the large LED display device may contain up to 256 units.

If more than 256 units are required, the number of possible codes may easily be increased by raising the number of switches in the address switching scheme. If, for example, the number of switches is raised from eight to ten, then $(2)^{10} = 1024$ different ten-bit codes are available. This is not, however, the preferred design since no switching scheme with ten switches is available on the market. An eight-switch element is available. The available eight-switch element is preferably employed for reasons of cost. In order to be able to employ the available switching scheme with 8 switches for more than 256 units, the number of output terminals at the interface is increased. Each interface output is linked to a group of 256 (or less than 256) units. Taking Figure 1B as a reference, if the purpose is to create a large LED display device (L2) with 1024 units, (U1 through (U1024), the units may be divided into four groups (G1), (G2), (G3), and (G4),

each of which contains 256 units, specifically, (U1) through (U256), (U257) through (U512), (U513) through (U768), and (U769) through (U1024). The number of output terminals for the interface must be increased to four. The output sites (g1), (g2), (g3), and (g4) are each linked to one group (G1), (G2), (G3), and (G4). The computer must be programmed so that it transmits the information relevant for a group (for example, (G2)) through the relevant output terminal (g2) to the group (G2). The interface (I1) in Figure 1B differs from the Interface (I) in Figure 10 and in Figure 1 only insofar as the number of its output terminals may be increased. Theoretically, the number of output sites may be increased indefinitely. As a result, the number of units on a large LED display device (L1) may be increased to any practical desired number while using the conventional eight-switch element.

As mentioned above, it is preferable not to select a number N for the panels of a unit which is either too large or too small. The reason for this will now be explained. Since each unit is provided with a corresponding control circuit which contains a CPU, RAM, data shift circuit, scanning driver circuit, and additionally, both an address switching scheme and a color brightness switching scheme, when N is too small (for example, N = 1, i.e., each unit contains only a single 8 x 8 dot panel), then 8 x 8 = 64 control circuits, and thus 64 element sets, are required if a large LED display device with 64 x 64 dots is to be created (although construction of some elements such as the buffer, data shift circuit, and scanning driver circuit is simpler when N is smaller). The resulting increase in cost is considerable. In addition, a significant amount of time is required to adjust the address switching scheme so that each of the 64 units receives the appropriate identification code and so that the units are linked to each other. If, however, N is too large (for example, N = 32), the possible combinations are significantly reduced. If, for example, a unit contains 2 x 4 = 8 panels, the large LED display device may be easily enlarged to a scale of 64 x 64 up to 96 x 80 dots by adding 7 such units containing eight-panels. If N = 32, then it is impossible to achieve this size. In addition, the panels of a unit must have the same level since the color brightness of the N panels in a unit may not be adjusted separately.

This means that the more value of N increases, the more difficult it becomes to find N panels with the same level, and the more difficult it also becomes to effect a "local adjustment." As a result, the selection of an optimal value N is a compromise between costs and the possibilities of achieving a combinable size and effecting a local adjustment. Taking all these factors into consideration, N = 8 seems to be the optimal value.

The inventions will be more readily understood if it is read in conjunction with the accompanying drawings.

Brief Description of the Drawings

Figure 1A is a diagram showing the connection between a large LED display device with eight units according to the invention and a computer with its assignment

plan for the units sketched in its memory; the associated illustration shows the positions of the eight units within the large LED display device.

Figure 1B is a diagram showing the connection between the large LED display device with four groups of units and an interface with four outputs.

Figure 1C is a diagram showing the connection between a row of circuit boards on the interface.

Figure 2 is a perspective view of a unit with 8 x 8 dot-matrix LED display panels according to the invention.

Figure 3 is a perspective view showing a large LED display device composed of eight of the units shown in Figure 2 and their connection to a computer.

Figure 4 is a short block diagram of the control circuit of one of the units in Figure 2.

Figure 5 is a diagram showing the connection between the outputs and inputs of the units in Figure 1A.

Figure 6 is a detailed circuit diagram showing a section of the control circuit with the address switching scheme and the color brightness switching scheme.

Figure 7 is a circuit diagram showing in the detail the wiring for the eight panels of a unit.

Figure 8 is a circuit diagram of the data shift circuit.

Figure 9 is a perspective view of an LED dot with a red and a green LED chip.

Figure 10 is a block diagram of a conventional, large dynamic dot-matrix LED display device composed of nine 8 x 8 dot-matrix panels.

Figure 11 is a perspective view of the large LED display device in Figure 10 and of its connection to a computer.

Detailed Description of the Preferred Embodiment

With reference to Figure 2, a unit (U) according to the invention contains an LED display board (27) which is composed of eight dot-matrix LED panels (P11) through (P24) and a control circuit (CC1). A current stabilizer (S) supplies the required current. In general, multiple units (for example, ten) may utilize a common current stabilizer. As mentioned above, the unit has an input terminal (1) and an output terminal (1') by which a number of identical units may be interconnected to create a large LED display device. Figure 3 shows a large LED display device (L1) which is created out of eight units (U1) through (U8), and is linked to a computer (C) through an interface (I) which corresponds to the interface (I) of Figure 11.

Figure 4 shows that the control circuit (CC1) of a unit contains a CPU (21), RAM (22), buffers (23) and (24), and a data shift circuit (25) (or DS1), and a scanning driver circuit (26) (or SC1). A current stabilizer (S) feeds the control circuit (CC1). Since these elements are analogous to the elements of prior art in Figure 10, their description below is reduced to a minimum.

As mentioned above, the control circuit of a unit contains an address switching scheme (31) and a color brightness scheme (32). These are each connected to the CPU through a buffer (311) and (321). Buffers (311) and (321) are each connected to a control

gate circuit (33). This circuit receives the signals from the CPU to control the transmission of buffers (311) and (321) to allow the appropriate signals to be gated.

In Figure 4, input site (1) is connected to the computer through an interface (I). The output of input terminal (1) contains a data transmission line (11), an address transmission line (12), and a control transmission line (13) which are connected to the input of the transmission buffer (23).

Transmission lines (111), (131) from transmission buffer (23) are connected to CPU (21), while transmission line (121) is connected to buffer (24), the output (121) of which is then connected to buffers (311), (321) and RAM (22). The three transmission lines (111), (112), (113) are each bifurcated and branch to output terminal (1'). When the transmitted data is not intended for this unit, it does not pass to the core of the unit but moves laterally through output terminal (1') to input terminal (1) of the next unit. Since the data passes through buffer (23) with an amplifier function, the data signal is not attenuated by passing through multiple units, even when a plurality of units must be traversed. A control transmission line (132) and a data transmission line (133) connect CPU (21) to RAM (22). One transmission line (112) runs from CPU (21) to the data shift circuit (25). Data shift circuit (25) sends the data from transmission line (112) to the appropriate dot rows of LED display board (27). Scanning of the rows of the LED display (26) is effected by scanning driver circuit board (27)[1] through the upper scanning transmission line (281) and lower scanning transmission line (291). The scanning transmission lines (28) and (29) run from RAM (22) to the scanning driver circuit. The row scanning signals are transmitted by CPU (21) through RAM (22) via scanning transmission lines (28, 29), scanning driver circuit (26), and scanning transmission lines (281, 291) to LED display board (27) in order to scan the board's sixteen rows.

Figure 5 shows in detail the connection of the terminals (1, 1') of the units shown in Figure 1.

Based on Figure 6, it is clear that both address switching scheme (31) and color brightness switching scheme (32) each contain eight ON/OFF switches. The eight ON/OFF switches of address switching scheme (31) may be used to produce 256 different binary codes. This means that a large LED display device may be composed of a maximum of 256 such units. Four of the eight switches of color brightness scheme (32) control the brightness of the red chips in the dots of this unit, while the remaining four switches control the brightness of the green chips. Using the four switches, $(2)^4 = 16$ different brightness levels may be set. The hue may similarly be adjusted by changing the ratio of red to green light. Assuming, for example, that the brightness of the red chip is at the 9th level and that of the green chip is at the 8th level, in the event the generated brightness is satisfactory while the hue is a little too red, the red chip may be set to the 8th

[1] Translator's note: *Sic.* Reference numbers 26 and 27 should be reversed.

level and the green chip to the 9th level. The result is that the brightness does not change while the hue is nevertheless corrected.

Data transmission lines (112) from CPU (21) to data shift circuit (25) contain a red light data transmission line (1121), a green light data transmission line (1122), a timing generator data transmission line (1123), and a scanning data transmission line (1124). Red and green light data transmission lines (1121), (1122) transmit information on the red and green components. The scanning signal enables the information on the red component and green component to be transmitted to the corresponding dots when the appropriate row is scanned.

Figure 7 shows that scanning transmission lines (281, 291) from scanning driver circuit (26) to LED display board (27) are each connected to the dots of the four upper panels (P11) through (P14), and to the dots of the four lower panels (P21) through (P24) so as to control the scanning of LED display (27).

Figure 8 shows that the four data transmission lines (1121) through (1124) are connected to data shift circuit (25). Data shift circuit (25) contains eight shift registers (SR1) through (SR4) and (SR1') through (SR4'), and eight driver stages (D1) through (D4) (red driver stages) and (D1') through (D4') (green driver stages). Red light data transmission line (1121) is connected only to the four shift registers (SR1) through (SR4), which are in turn connected to the red chips of board (27), while green light transmission line (1122) is connected only to the four shift registers (SR1') through (SR4'), which are in turn connected the green chips on board (27). Each driver stage has eight outputs, each of which is connected to a column of LED display (27). Since the description presented in the above three paragraphs refers to known technical processes and is not part of the invention, additional details may be omitted.

The brightness of the LED chip is controlled by the pulse duration. As mentioned above, the brightness of an LED chip is determined by the power supplied to it. Since the average current is directly related to the pulse duration which energizes the LED chip, brightness may be adjusted by modifying the pulse duration. CPU (21) is able to determine the state of the color brightness switching scheme and to transmit pulses of the corresponding duration through red light transmission line (1121) and green light transmission line (1122) to the red and green LED chips, thereby generating the desired level of color brightness in the LED dot.

In the preferred embodiment, adjustment of color brightness proceeds in steps. In other words, the brightness of the LED chip is divided into sixteen different levels. A continuous adjustment is also possible using different conventional equipment.

It is worth mentioning that theoretically the units may be connected in series in varying numbers. If they are connected in parallel, however, the number of units connected in parallel in a dot should not exceed ten since the signal issued by the computer must be split for each branch of the parallel circuit, and may thus become weaker. If the ramification number exceeds ten, the signal may become so attenuated that operation is no longer possible.

In order to construct a large LED display device with 256 units, the 256 units must first be assigned different codes by setting address switching scheme (31) and then connected to their terminals to create a closed circuit. The large LED display device thus created must then be linked to the computer through an interface.

The "assignment plan" must then be entered in the computer. The "plan" may be generated by inputting a "plan program" in the memory of the computer, or, alternatively, by cycling through a "mapping program" which, as mentioned above, sketches a "plan" in the computer.

In order to enlarge or reduce the scale of a large LED display device (L'), a selected number of units may be added to the original large LED display device (L') (or a selected number of units removed from it) and the appropriate identification code assigned to the added units. (If necessary, the identification codes of the old units in the original large LED display device may have to be replaced). The units of the new large LED display device may then be reassigned with the addresses of the computer, and the "assignment plan" in the computer refreshed by replacing the "old plan" with a new one, or by again cycling through the "mapping program." The modified large LED display device will then be usable.

As mentioned above, the number of output terminals of the interface may be increased if more than 256 units are required and the available eight-switch element is used. Figure 1C shows that a circuit board (W) of the interface may contain eight output terminals (g1) through (g8), of which each is connected to the 256 units by a group (g1) through (g8)[2]. Each circuit board (W) has an input end (X) and an output end (Y). This allows the circuit boards (W) to be connected in any number in series. It is of course obvious that the data from a given group, such as third group (G3), are transmitted only to the relevant output terminal (g3) of the first circuit board (W), and not to the other output terminals. This process is controlled by the computer. By linking three such circuit boards, 24 output terminals may be provided. This means that 24 groups, or 256 x 24 = 6144 units, may be incorporated into a large LED display device.

The invention offers numerous advantages over conventional dynamic dot-matrix LED displays. Since the unit may be standardized, its price is kept to a minimum. The units may be combined in any desired number to create a large LED display device of the desired size without the requirement that the circuit be redesigned or the software in the CPU be reprogrammed. Since the level of color brightness for each individual unit may be adjusted separately, the requirement that the panels be uniform is not critical, as is the case with conventional LED displays, and any slight nonuniformity in terms of brightness

[2] Translator's note: *Sic.* Should be G1 and G8.

or hue at each site of the resulting large LED display device may be eliminated by local adjustment. There is no doubt that this invention is a revolutionary breakthrough for the fabrication of LED displays.

Claims

1. A dot-matrix LED display unit for constructing a large LED display device which reproduces the saved pattern information stored in a computer, comprising: a dot-matrix LED display board and a control circuit, wherein the dot-matrix LED display board contains m x n LED dots, n and m being integers, and each of the LED dots contains at least one LED chip for monochromatic light, and wherein the control circuit contains an input terminal connectable to the computer; a CPU which is connected to the input terminal and memory devices which are connected to the CPU; a plurality of buffer devices; a data shift circuit which coincides with the m columns of the LED dots on the board, and a scanning driver circuit which coincides with the n rows of LED dots, wherein the CPU contains software programmed so that the scanning driver circuit performs cyclic scanning through the n rows from the first to the n^{th} row, and the data shift circuit transmits the appropriate information from the computer to the LED dots of a corresponding row which is scanned by the scanning driver circuit, **characterized in** that the control circuit is provided with an output terminal and an addressing device in which an identification code is stored, wherein the output terminal is structurally connectable to the input terminal and is connected to the interconnection lines between the input terminal and the CPU, and wherein the identification code matches a specific address of the computer's memory, the software of which is designed such that when data with an addressing signal is transmitted by the computer, and the addressing signal matches the identification code, the unit enables the display of the data on the LED display board.

2. Dot-matrix LED display unit according to Claim 1, in which each of the LED dots contains at least two LED chips, each with a different monochromatic light.

3. Dot-matrix LED display according to Claim 2, additionally including an adjustment device to adjust the brightness of the different monochromatic light of each LED chip.

4. Large LED display device, created from a plurality of dot-matrix LED display units according to Claim 1, characterized in that the input terminal of at least one unit is connected to the computer, and the input terminal of each of the remaining units is connected to at least one of the input terminals and output terminals of at least one additional unit, and each of the units has its own identification code.

5. Dot-matrix LED display unit according to Claim 1, in which the addressing unit contains a plurality of ON/OFF switches, and the identification code is created by the position of the switches.

6. Dot-matrix LED display unit according to Claim 3, in which the adjustment device contains a plurality of ON/OFF switches, and the different brightness levels of the LED chips correspond to the positions of the switches.

7. Dot-matrix LED display according to Claim 1, in which $m = 16$ and $n = 32$.

8. Dot-matrix LED display unit according to Claim 1, in which the dot-matrix LED display board is created by 2 x 4 = 8 panels having an 8 x 8 LED dot matrix.

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